CASE STUDY

SCQUAIR: Small Changes, QUANT and AI Resilience - Simulating the Resilience of Transport Infrastructures using QUANT

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Introduction

The SCQUAIR project simulates the pattern of land use and transportation for England, Scotland and Wales, running myriad simulations to identify the impact of new jobs, in terms of where people live and how they travel there.

The underlying spatial interaction model is called QUANT, developed by Professor Michael Batty of UCL, and runs very rapidly in a web-based environment.

It is configured in terms of thousands of small zones and three modes of transport (bus, rail, road) which bind together employment at place of work and population at place of residence.

The SCQUAIR project involved teaching artificial intelligence (AI) to add scenarios to QUANT which project the magnitude and direction of people commuting, the differences in kilometres travelled when new transport options are introduced, the impact of job swaps between regions on road kilometres driven, and the transport they use to commute, as well as other elements.

Who's involved?

SCQUAIR is led by Dr Richard Milton, Senior Researcher, Bartlett Centre for Advanced Spatial Analysis (CASA), UCL. When on secondment to the Alan Turing Institute for AI and Data Science, Richard developed the current evolution of the "QUANT" spatial interaction model with an emphasis on AI for building new transport infrastructure scenarios for carbon net zero. His Co-Investigator for SCQUAIR is Professor Michael Batty, Emeritus Professor of Planning at UCL's CASA, together with Xinyi Liu and Yuet Yung Lung from UCL.

When did the project start and finish?

October 2023 to June 2024

Key challenges that SCQUAIR aims to solve

The QUANT model and its application for simulating the resilience of transport infrastructures is optimised to deliver results to the user in a matter of minutes, so that users can speedily derive and test future scenarios for land use and transport.

The model looks at 'what-if' scenarios so users can run thousands of scenarios around the use of land and transport, to predict impacts and to enable stakeholders to test various plans.

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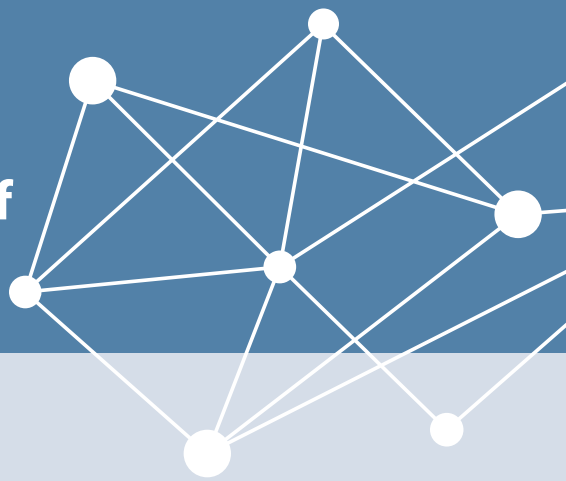

It also demonstrates how AI can be used to inform the generation of many scenarios, helping move planners from restrictions of current human or traditionally-generated computer planning.

Scenarios can include the impact of shocks to the land by new infrastructures, such as Britain's HS2 (High Speed Two) high speed railway project.

QUANT is able to carry out complex calculations very fast, by using AI to investigate myriad scenarios, and in turn, AI is able to help humans see possibilities that might otherwise be missed.

Of the three modes of travel within QUANT, road variations are hard to predict, rail is comparatively easy, and bus is easy to moderate to predict. The challenge around roads is due to the myriad of network possibilities that roads allow, whereas rail has definite routes and rail stations.

What was the key aim of the project?

Within the SCQUAIR project, the team aimed to adapt the 'what-if' scenario capability of QUANT to the DAFNI platform, so that users could run thousands of scenarios.

The data from the scenario runs can be used by urban planners to show how future plans for the location of land uses and transport can be massively improved – optimising outcomes for the carbon budget, for example.

What did DAFNI allow you to do that you couldn't otherwise have achieved?

With SCQUAIR on DAFNI, models such as QUANT can be used effectively to predict the impacts of future land use and transport scenarios, and generate the impacts of shocks to the land use transport system, including those posed by new infrastructure projects, such as HS2, which are complex and continually evolving.

The project started out with each scenario run taking 3.5 minutes, which with DAFNI has now reduced to 4 seconds. This is a huge saving when 1 million or more scenario runs might be required.

Researchers working remotely across continents can collaborate together, using DAFNI to run high performance scenarios.

DAFNI is also useful for storing data and running the code. Many people were interested in running a spatial interaction model but finding it hard to manage the inputs and outputs.

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What outputs from the project have you put onto the DAFNI platform?

The SCQUAIR model is now available on the DAFNI platform.

Richard also plans to upload a more general model which will allow researchers to run more general scenarios.

How do you anticipate other researchers, policymakers and stakeholders using this work?

Transport and urban planners, researchers and policymakers will use this work. It allows them to run the computational aspects and the human data visualisation on a map.

DAFNI and SCQUAIR could be used to run high impact workflows, for example, if a large part of London were to flood, what would this mean in terms of how people relocate?

As an example, with Heathrow's plans for a third runway, QUANT was used to input government data on the number of new jobs as outlined in the government White Paper on the proposed expansion of the airport. QUANT was then used to demonstrate where people would want or need to live in order to get a job at the third runway 'Heathrow Zone'. QUANT can identify how many road or rail kilometres would be required to commute from those living areas to the working areas, and can help planners to identify improvement measures, such as a new rail line or other new infrastructure.

It can also be used for more complex network, employment and housing scenarios, using AI to allow planners to investigate far beyond the scope of human planners, and identify where there is a geographically bigger impact for a smaller cost.

What would you identify as the main impact of this work?

QUANT is a very visual way to investigate possibilities – planners can look at a map and create a visualisation that they can use to identify most positive and negative impacts – from positive travel mitigations to negative carbon outcomes.

Without SCQUAIR, planners would need to do many computational runs to capture scenarios, to plan for a sizeable new development such as the third Heathrow terminal, together with complex calculations and the associated time and costs.

Thousands of computer and real-world scenarios can be run using SCQUAIR, to test and measure many variables, from numbers of people travelling, to costs, distances travelled in kilometres, carbon impact, and more.

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How could this work benefit society as a whole?

The visualisations combined with the depth of the data is incredible. SCQUAIR includes 3 modes of transport with 8500 zones in the model and a radius of 5 km. (Ferry is included in the bus mode as the timetables are common.)

Different variables can be selected and visualised on a map. Planners can investigate and demonstrate whether impacts are being driven by the network changes, and can even use an emulator model to predict what the impacts will be, without running the whole model.

For example, if planners or researchers have a proof of theory, they can take a huge monolithic project such as HS2 and break it into smaller pieces - the 'smaller plans' route. Viewing a huge project as a series of smaller ones can help more clearly identify impacts and help to de-risk the project.

SCQUAIR will likely lead to improved outcomes for transport and urban planning. For example, if new jobs attract people to an area, where will people live, how will they travel to work, and the carbon impacts; and conversely, the impacts of a new rail link running from A to B, making it easier and cheaper to travel to work.

Essentially, QUANT can help improve infrastructure planning for better job accessibility, and to help people get home more easily afterwards.

What are the next steps?

Richard has submitted a paper for the Conference on Computational Urban Planning and Urban Management (CUPUM), which CASA is hosting in June 2025.

A further 2 or 3 papers are also planned, with one to explore the side of human AI – looking at playing the human planner against the computer-generated planner, and another to explore scenarios in the Hong Kong bay area.

Updates and further developments to the QUANT model are also in the pipeline!